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Evaluation of Learning and Memory Enhancing Activity of Aqueous and Ethanolic Extracts of *Sida Veronicaefolia* In Rat

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ABSTRACT

This study was designed to evaluate, learning and memory enhancing activity of aqueous and ethanolic extracts of whole plant of *Sida veronicaefolia* in rats using Elevated plus maze(EPM), Hebb William Maze(HWM), and Morris water maze(MWM) and to evaluate brain Acetylcholine esterase activity ,lipid peroxidation, superoxide dismutase activity, catalase and glutathione level. Rats were divided into 7 groups of 6 no each. Group 1(control) animals received vehicle , Group 2 animals received scopolamine (0.4mg/kg i.p.), on 19th and 27th day only, Groups 3 and 4 animals received 200mg/kg and 400mg/kg p.o. of aqueous extraction of *Sida veronicaefolia.* Group 5 and 6 animals received 200mg/kg and 400mg/kg p.o. of ethanolic extraction of *Sida veronicaefolia* and Group 7 animals received piracetam (400mg/kg i.p.) for 27 days, followed by scopolamine (0.4mg/kg i.p.) single dose on 19th and 27th day only. Assessment of transfer latency (TL), time taken to reach reward chamber (TRC) and assessment of swim latency (SL) was one on 19th and 27th day using elevated plus maze, Hebb William maze and Morris water maze. Animals were sacrificed on 27th day, brain acetylcholine esterase activity, lipid peroxidation, superoxide dismutase activity, catalase activity and glutathione level were estimated. The data was expressed as mean ± S.E.M. The statistical analysis was done by means of ANOVA followed by Dunnett's post hock test. The aqueous and ethanolic extracts of *Sida veronicaefolia* decreased Tranfer Latency, Time taken to reach Reward Chamber and Sim Latency in comparison to scopolamine treated rats, decreased acetylcholine esterase activity and lipid peroxidation and increased super oxide dismutase, glutathione and catalase activity in brain.

Keywords: Learning, Memory, EPM, HWM, MWM, Piracetam, Scopolamine

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INTRODUCTION

The brain is the center of the nervous system which controls memory, thought, reason judgement, consciousness and emotion.[1] The hippocampus is the major component of the brain of humans which plays an important role in the long term memory. Memory is the ability of an individual to record sensory stimuli, events, information etc., retain them over a short or long period of time and recall the same at later when needed.[2] Learning is the process of acquiring new knowledge while memory is the process of encoding, storage and retrieval of acquired knowledge.[2] Memory is the natural counter part of learning. Poor memory, low retention and slow recall are common problems in today's stressful and competitive world. Age, stress, emotions are conditions that leads to cognitive disorders.[3]Cognitive deficits have long been recognized as severe and consistent neurological disorders associated with numerous psychiatric and neuro-degenerative states such as senile dementia, multi-infract dementia, Parkinson's disease, Huntington's chorea etc[4] and Alzheimer's disease, amnesia, delirium, depression, schizophrenia etc. are the results of impairments in learning and memory.[5]Herbal medicines derived from plant extracts are being increasingly utilized to treat a wide variety of clinical diseases, though relatively little knowledge about their mode of action is available. There is growing interest in the pharmacological evaluation of various plants used in Indian traditional systems of medicine.[6] Many herbal remedies are used to improve learning and memory. The plant *Sida veronicaefolia* commonly known as "nagabala" belonging to the family Malvaceae, herbs is found in East Asia such as India, Srilanka, Thailand, Myanmar, Vietnam, etc. It is grown in hotter parts of India. It grows in tropical countries, but can also grow in stony and hilly regions. But abundantly found in Bihar, Rajasthan and Konkan. This herb is considered as the nervine tonic and offers with various other health benefits. It acts as the aphrodisiac and anti-aging herb. This plant is packed with demulcent, anti-acidic, expectorant, antipyretic, diuretic, aphrodisiac, carminative and cardiac properties. It is used in treating bleeding disorders, dysuria.[7] several studies indicated that *Sida veronicaefolia* has Hepatoprotective activty[8], Antioxidant activity[9], Antitumour activity[10]. Extensive literature revealed that *Sida veronicaefolia* possess learning and memory enhancing activity but failed to get the scientific documentary evidence. Hence present study was taken up to investigate learning and memory enhancing activity of *Sida veronicaefolia.*

MATERIALS AND METHOD

Plant material:

The whole plant of *Sida veronicaefolia* were collected from Tirupati, India and authenticated by

Dr.K. Madhava Chetty, Sri Venkateshwara University, Tirupati, India.The authenticated aqueous and ethanolic extracts of *Sida veronicaefolia* was obtained from 'Green Chem', Bangalore-560071.

Chemicals and drugs:

Scopolamine was taken from BUSCOPAN injection, (CADILLA HEATH CARE). Piracetam was taken from NEUROCETAM injection (MICRO LABS LIMITED) Bangalore.

Experimental Animals:

Inbred, young Wistar rats (160 ± 10g) were used in the current study. The animals were maintained under standard laboratory conditions of room temperature 24 ± 5˚ C, relative humidity 45-55% and natural day and night cycle. The animals had free access to food (standard rat pellet) with water supplied *ad libitum*. All the experiments were conducted in compliance to ethical principles and guidelines provided by Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA). Permission was taken from IAEC of Visveswarapura Institute of Pharmaceutical Sciences, Bangalore.

Experimental protocol:

Wistar albino rats were divided into seven groups of six rats each for all the three models (EPM, HWM, MWM). Group-I animals served as control, received vehicle i.e, distilled water. Group-II animals received scopolamine 0.4 mg/kg i.p.[11] Group III and Group IV animals received low dose and high dose of aqueous extraction of *Sida veronicaefolia* (200 and 400mg/kg p.o.)[10] Group V and VI animals received low dose and high dose of ethanolic extraction of *Sida veronicaefolia* (200 and 400mg/kg p.o.)[10]. Group-VII animals, received piracetam 400 mg/kg i.p.[12] The rats of group III, IV,V,V1 and VII received the respective treatment for 15 days, followed by training session on 16th, 17th, and 18th day. On 19th day, single dose of scopolamine was administered to all the animals except group I animals, 30 min after the respective treatment. TL, TRC, and SL were assessed 45 min thereafter respectively. The respective treatments continued for one week and on 27th day, scopolamine was administered to all the animals except group I animals, 30 min after the respective treatment. TL, TRC, and SL were assessed 45 min thereafter respectively.

Elevated Plus Maze (EPM):

At the start of the trial the rat is placed individually at one end of an open arm facing away from the central square. The time taken by rat to move from open arm and enter into one of the closed arm with all its four legs is recorded as initial transfer latency (ITL) using a stopwatch. To become familiar with the maze, the rats are allowed to move freely in the apparatus for 30 sec after reaching the closed arm and then returned to its home cage. Retention transfer latency (RTL) of this learned task (memory) is examined 24 hrs after the first day trial. The duration of this test is 300 sec. After

each test the apparatus is cleaned with 70% ethanol to remove any olfactory clue. In the EPM test, the measures analyzed are ITL and RTL. If the rat did not enter into one of the closed arm within 300 sec, is eliminated from the experiments.[13]

Hebb- William Maze

Each rat is placed in animal chamber (Start box) and door is opened to facilitate the entry of animal into the next chamber. The door of start box is closed immediately after the animal moved in to the next chamber so as to prevent its back entry. Time taken in seconds by the animal to reach reward chamber (TRC) from the start box is noted for each animal. Each animal is allowed to explore the maze for additional 20 seconds, with all its doors opened before returning to its home cage. A fall in TRC on subsequent maze exposures is taken as an index of successful retention.[14]

Morris Water Maze (MWM)

In acquisition trial a rat is placed in the middle of a compartment of the tank, facing the wall of the tank and allowed to explore the submerged platform for 300 sec. A trial is finished as soon as the rat has mounted onto the platform. If the rat is failed to find the platform within 300 sec, it is directed toward the platform. In both of this case a rat is allowed to stay on the platform for 30 sec. Each rat is subjected to four consecutive trials each day with a different starting point, in random order. The platform is always in the same quadrant (south). Escape latency (EL) is the time taken to find the submerged platform. The EL and time spent in the target quadrant (TSTQ) are recorded using a stopwatch. After completion of the fourth trial, the rat is gently dried with a soft cloth and kept warm under a 150-Watt bulb within the home case. After the fourth trial of the last day (14th day), a probe trial is given. The platform is removed and the time spent in the target quadrant (TSTQ) and all the three quadrants is measured for 60 sec. In the probe trial, all rats started from the same starting position, opposite to the quadrant (south) where the platform had been positioned during acquisition. The TSTQ and time spent in the annuli (TSA) were recorded using a stopwatch

In the MWM test, for acquisition trial the measures analyzed are EL and TSTQ. For probe trial the measures analyzed are TSTQ and TSA.[15]

BIOCHEMCAL ESTIMATION

Sampling of brain tissue:

The animals were sacrificed after the treatment i.e., on 28th day, whole brain was carefully removed from skull. For preparation of brain homogenate, the fresh whole brain was weighed and transferred to a glass homogenizer and homogenized in an ice bath after adding 10 volumes of 0.9% w/v sodium chloride solution. The homogenate was centrifuged at 3000rpm for 10 min and

the resultant cloudy supernatant liquid was used for estimation of brain acetylcholine esterase activity, lipid peroxidation, superoxide dismutase, catalase and glutathioneactivity.[16]

Assay of acetylcholinesterase activity in the brain

The method of AChE activity estimation is popularly known as Ellman's method named after George Ellman who developed this method in 1961. The esterase activity is measured by providing an artificial substrate, acetylthiocholine (ATC). Thiocholine released because of the cleavage of ATC by AChE is allowed to react with the -SH reagent 5,5'-dithiobis-(2-nitrobenzoic acid) (DTNB), which is reduced to thionitrobenzoic acid, a yellow coloured anion with an absorption maxima at 412 nm. The extinction coefficient of the thionitrobenzoic acid is 1.36×104/molar/centimetre. The concentration of thionitrobenzoic acid detected using a UV spectrophotometer is then taken as a direct estimate of the AChE activity.[17]

Measurement of lipid peroxidation:

Ohkawa et al., (1979) method was used to determine lipid peroxidation in tissue homogenate spectrophotometrically. Here one molecule of malondialdehyde (MDA) reacts with two molecules of 2-thiobarbituric acid (TBA) at pH 3.5. The pink chromogen was measured spectrophotometrically at 532 nm with extinction coefficient of 156 mM^{-1} cm^{-1}. [18]

Measurement of glutathione levels:

Ellman (1959) was used to measure the Glutathione in brain tissue homogenate.SH group of glutathione reduce 5,5'-dithiobis-(2-nitrobenzoic acid) (DTNB) to form 2-nitro-S-mercaptobenzoic acid per mole of glutathione. The reduction product is measured spectrophotometrically at 412 nm using the extinction coefficient of 13.6 $mM^{-1}cm^{-1}$ [19]

Measurement of catalase activity

Catalase activity was determined spectrophotometrically by the method of Aebi et al (1984). Catalase

$2H_2O_2 \rightarrow 2H_2O + O_2$

Catalase catalyzes the decomposition of hydrogen peroxide according to the above equation. The decrease in absorbance at 240 nm was followed for one min.[19]

Measurement of superoxide dismutase activity

Superoxide dismutase activity in brain homogenate was determined spectrophotometrically. In superoxide dismutase assay, ions are generated from the conversion of xanthine touric acid and hydrogen peroxide in presence of xanthine oxidase (XOD), these ions converts NBT to NBT-diformazan. This NBT-diformazan absorbs light at 560 nm. SODs reduce superoxide ion

concentrations and thereby lower the rate of NBT-diformazan formation. The extent of reduction in the appearance of NBT-diformazan is a measure of SOD activity.[19]

Statistical analysis

All the values are expressed as Mean ± SEM. The data was analyzed by one way ANOVA, followed by Dunnett's test. $P \leq 0.05$ was considered significant.

RESULTS AND DISCUSSION

Preliminary qualitative photochemical analysis of aqueous and ethanolic extraction of *Sida veronicaefolia.*

Aqueous extraction of *Sida veronicaefolia* contains reducing sugars, and alkaloids, steroids. Ethanolic extraction of *Sida veronicaefolia* contain carbohydrates: non-reducing sugars, steroids, alkaloids, glycosides, flavonoids, tannins and phenolic compounds, saponins.

Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on transfer latency (TL) using EPM

As shown table 1, scopolamine increases the time taken by rat to reach the closed arms as compared to control group,(i.e.induces amnesia).Pretreatment with aqueous and ethanolic extracts *Sida veronicaefolia* (200&400mg/kg) for 27 days, resulted in decrease in TL , in dose dependent manner, which was comparable with Piracetam(400mg/kg).Ethanolic extract of *Sida veronicaefolia* decreased TL significantly($P<0.01$) on day 27^{th} as compared to 16, 17, 18 and 19^{th}.

Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on time taken to reach reward chamber (TRC) using HWM.

As shown figure 1 scopolamine increases the TRC as compared to control group, (i.e. induces amnesia). Pretreatment with aqueous and ethanolic extracts *Sida veronicaefolia* (200&400mg/kg) for 27 days, resulted in decrease in TRC, in dose dependent manner, which was comparable with Piracetam (400mg/kg). Ethanolic extract of *Sida veronicaefolia* decreased TRC significantly ($P<0.01$) on day 27^{th} as compared to 16, 17, 18 and 19^{th}.

Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on Swim latency(SL) using MWM

As shown figure 2 scopolamine increases the SL as compared to control group,(i.e. induces amnesia). Pretreatment with aqueous and ethanolic extracts *Sida veronicaefolia* (200&400mg/kg) for 27 days, resulted in decrease in SL, in dose dependent manner, which was comparable with Piracetam (400mg/kg). Ethanolic extract of *Sida veronicaefolia* decreased SL significantly ($P<0.01$) on day 27^{th} as compared to 16, 17, 18 and 19^{th}.

Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* free radical scavenging potential.

As shown table 2, scopolamine increases LPO activity and decreases the SOD, Catalase and Glutathione activity. Pretreatment with aqueous and ethanolic extracts of *Sida veronicaefolia* , for 27 days, resulted in significant (P<0.01) decrease in LPO and increase in SOD, Catalase, Glutathione activity, in a dose dependent manner, which was comparable with Piracetam(400mg/kg).

Memory is the ability of an individual to record sensory stimuli, events, information etc., retain them over a short or long period of time and recall the same at a later date when needed. Learning is the process of acquiring knowledge about the world and memory could be considered as the retention of the acquired knowledge, which can be retrieved as and when, required. Memory function is vulnerable to a variety of pathologic processes including neuro- degenerative diseases, strokes, tumors, head trauma, hypoxia, cardiac surgery, malnutrition, attention-deficit disorder, depression, anxiety and the side effects of medication, and normal ageing.[20] Nootropics are agents that improve mental functions such as memory, intelligence, motivation, attention, concentration, cognition and increase blood circulation to brain. Although there is no proper cure for cognitive impairment, alternative pharmacology treatment modulates can reduce the symptoms of memory loss and slow disease progression.[21] Herbal drugs have shown the promising effect in the treatment of memory loss.[22] Nootropics popularly referred as smart drugs, boost human cognition ability. Nootropic agents such as piracetam, pramiracetam and choline esterase inhibitors like donepezil are being used to improve memory. However, the resulting adverse effects associated with these agents makes it necessary explore the utility of traditional medicine in treatment of various cognition disorders.[23] The present study was undertaken to evaluate the learning and memory enhancing activity of aqueous and ethanolic extracts of *Sida veronicaefolia* in amnesic rats using Elvated Plus Maze, Hebb-William Maze and Morris Water Maze.

In the present study, scopolamine and diazepam induced amnesia in rats. Aqueous and ethanolic extracts of *Sida veronicaefolia* at dose of 200 mg/kg and 400 mg/kg body wt, p.o. were effective in reversing amnesia when memory retention was evaluated in exteroceptive behavior model of Elevated Plus Maze, Hebb William Maze and Morris Water Maze. Learning and memory enhancing activity of test drugs were effective dose dependently. As from the results obtained from experiments, aqueous and ethanolic extracts of *Sida veronicaefolia* was found to be effective in reducing transfer latency, time taken to reach reward chamber and swim latency in scopolamine induced amnesic rats using EPM, MWM, HWM respectively, reduction in acetylcholine esterase activity, reduction in LPO level and increase in SOD, GSH, Catalase level in dose dependent manner. This can be interpreted as the learning and memory enhancing activity of aqueous and

ethanolic extracts of *Sida veronicaefolia*, which may due to it's antioxidant properties. The preliminary phytochemical analysis of aqueous extract of *Sida veronicaefolia* showed presence of flavonoids, polyphenols, phenethylamines, Quinazoline, gossypol, linoleic acid and ethanolic extract of the plant contain saponins, pseudo tannins, flavonoids, alkaloids, phenolic compounds choline and oxalic acid.[8] which show antioxidant activity according to earlier studies. Hence this antioxidant activity of *Sida veronicaefolia* may be responsible for enhancing learning and memory in rats.

Scopolamine interferes with memory and cognitive function in human beings and experimental animals, by blocking the muscarinic receptors (M1) and inhibits the action of acetylcholine at the receptors.[24] The animal models have been extensively used in research to screen drugs with potential therapeutic value in dementia. The Elevated Plus Maze, Hebb William Maze and Morris Water Maze were used to screen the effectiveness of test drugs in amnesic rats. The aqueous and ethanolic extracts of *Sida veronicaefolia* in dose of 200 mg/kg and 400 mg/kg body wt p.o. for 27 days diminished amnesia in rats which is induced by scopolamine and diazepam. These extracts also prevented scopolamine and diazepam induced impairment of memory when evaluated in all the three models. The Elevated Plus Maze, Hebb William Maze and Morris Water Maze, are used to investigate spatial memory and learning. It is especially sensitive to impaired cholinergic hippocampal function, hence suggesting attenuation of scopolamine induced spatial learning deficit in rats by aqueous and ethanolic extracts of *Sida veronicaefolia.*

Age, oxidative stress, harmful free radicals and inflammation are some of the components in the development of memory impairment, including the conditions such as dementia, schizophrenia and Alzheimer's disease.[2] The oxidative stress, generation of free radicals, harmful by products of oxidative metabolism are known to cause organic damage to the living system. It is hypothesized that increasing antioxidant levels in the organism might retard or reverse the damaging effects of free radicals on neurons. Oxidative stress in brain generates free oxygen radicals like superoxide anion, hydroxyl radical, and hydrogen peroxide, which act on polyunsaturated fatty acids in brain. The major antioxidant and oxidative free radical scavenging enzymes like SOD, glutathione, and catalase play an important role to reduce oxidative stress in brain. In the present study after scopolamine (27th day) treatment rats showed a significant increase in lipid peroxidation levels in brain. At the same time there was a significant reduction in levels of glutathione, a tripeptide found in all cells, which reacts with free radicals to protect cells from superoxide radical, hydroxyl radical and singlet oxygen. Pretreatment of aqueous and ethanolic extracts of *Sida veronicaefolia* reduced the lipid peroxidation levels and increased GSH content in brain. Scopolamine reduced the SOD

activity in brain. SOD is the only enzyme that uses the superoxide anions as the substrate and produces hydrogen peroxide as a metabolite. Superoxide anion is more toxic than H_2O_2 and has to be removed.[2] Pretreatment with aqueous and ethanolic extracts of *Sida veronicaefolia* significantly prevented the reduction of SOD activity in brain. Also there was a decrease in catalase level in scopolamine induced amnesic rats. Pretreatment with aqueous and ethanolic extracts of *Sida veronicaefolia* increased the catalase levels in rat brain. The results suggest that the aqueous and ethanolic extracts of *Sida veronicaefolia* reduced oxidative stress by reducing lipid peroxidation and increasing the endogenous antioxidant enzymes in brain. Thus the present study demonstrates that aqueous and ethanolic extracts of *Sida veronicaefolia* has potential anti-amnesic effects through inhibition of lipid peroxidation, augmentation of endogenous antioxidant enzymes and decrease in acetylcholinesterase (AChE) activity in rat brain.

Table 1: Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on Transfer latency (TL) in scopolamine induced amnesic rats by using Elevated Plus Maze.

Treatment	TL on 1st day (sec)	TL on 2nd day(sec)	TL on 16th day(sec)	TL on 17th day(sec)	TL on 18th day(sec)	TL on 19th day(sec)	TL on 27th day(sec)
Control	58.11 ±0.84	56.89 ±1.15	57.18 ±0.99	55.29 ±1.62	49.99 ±1.23	39.06 ±1.33	36.22 ±1.13
Scopolamine (0.4mg/kg)	58.15 ±0.96	57.76 ±12	58.1 ±0.48	57.01 ±0.80	50.33 ±2.09	49.79 ±1.21	51.81 ±1.54
LDAESV(200mg/kg)	58.49 ±0.65	57.44 ±0.62	57.52 ±0.56	54.07 ±1.69	48.51 ±2.05	46.20 ±1.43	41.03 ±1.65
HDAESV(400mg/kg)	59.24 ±0.92	57.68 ±1.12	57.37 ±0.60	52.71 ±1.75	46.91 ±0.91	40.92 ±1.95	37.36±2.09**
LDEESV(200mg/kg)	58.2 ±1.26	58.11 ±0.80	56.42 ±0.61	53.12 ±2.33	47.78 ±1.09	41.36 ±2.89	38.21 ±1.82
HDEESV(400mg/kg)	58.61 ±1.52	57.22 ±0.60	56.19 ±0.34	51.68 ±2.49	45.87 ±0.56	38.15±1.80**	29.66±4.28**
Piracetam (400mg/kg)	58.53 ±0.75	57.12 ±0.78	53.54 ±0.74	47.67 ±1.37	41.37±2.56**	35.43±1.69**	24.57±1.58**

n=6, Values are expressed as mean ± SEM, One way ANOVA followed by Dunnett's test.

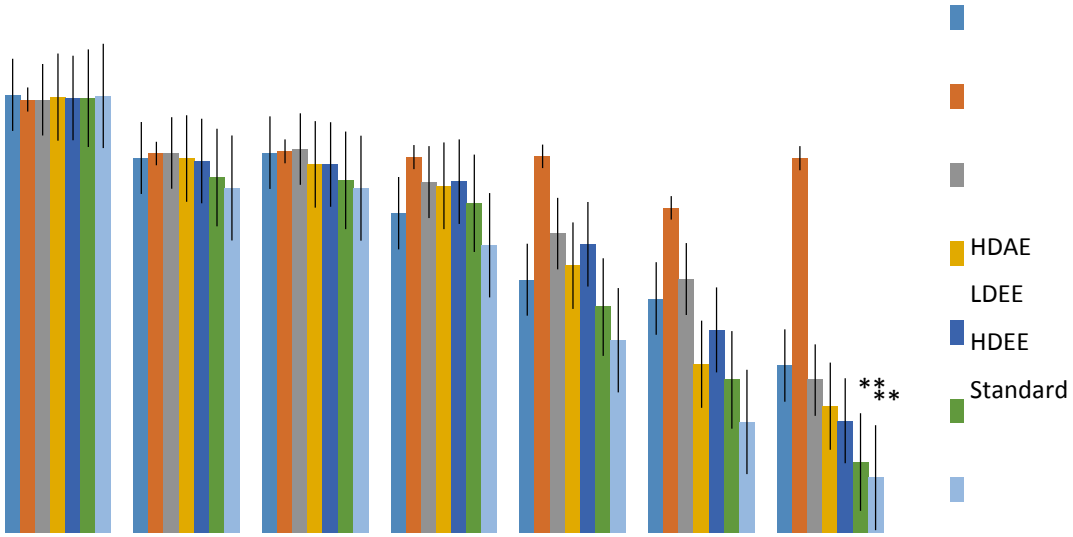

Figure 1: Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on time taken to reach reward chamber (TRC) in diazepam induced amnesic rats by using Hebb-William Maze.

n=6, Values are expressed as mean ± SEM , One way ANOVA followed by Dunnett's test.

*P<0.05v/s scopolamine control,** P <0.01v/s scopolamine control.

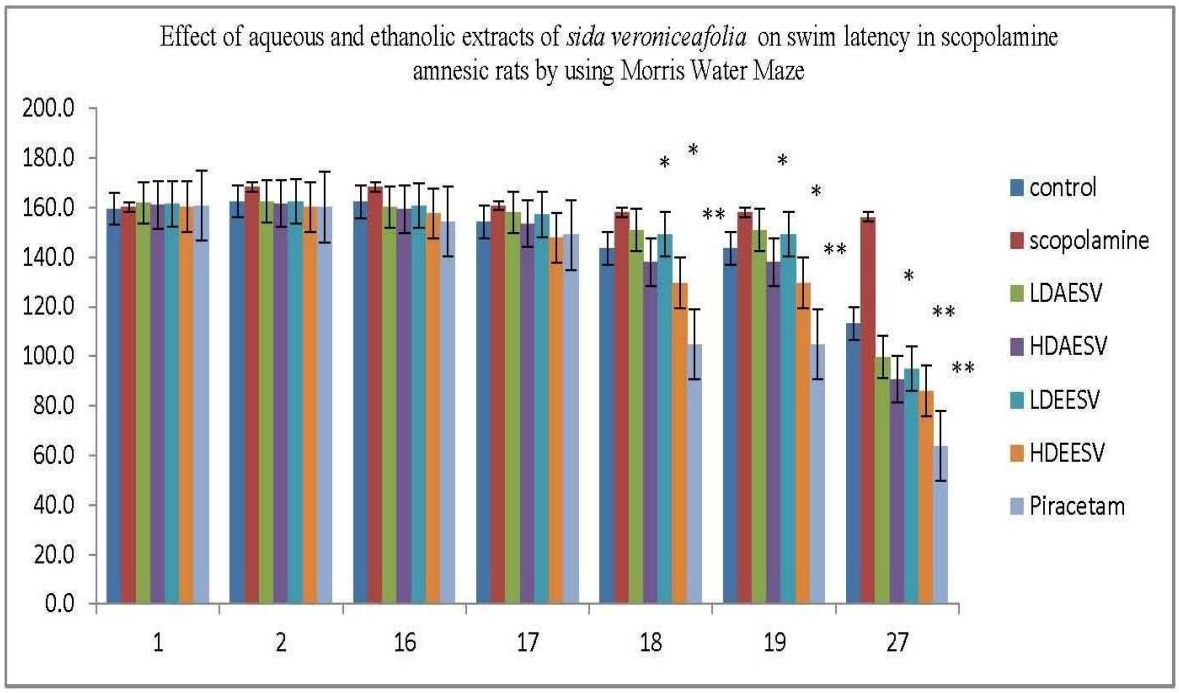

Figure 2: Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* on Swim Latency (SL) inscopolamine induced amnesic rats by using Morris Water Maze.

n = 6 Values are expressed as mean ± SEM, One way ANOVA followed by Dunnett's test.

*P<0.05v/s scopolamine control,** P <0.01v/s scopolamine control.

Table 2: Effect of aqueous and ethanolic extracts of *Sida veronicaefolia* free radical scavengingpotential in scopolamine induced rats using Elevated plus maze.

Treatment	AChE activity in µmole/min/gm tissue	Lipid peroxidation in moles/gm of tissue	Glutathione in moles/gmof protein	Superoxide dismutase in moles/gm of protein	Catalase in U/mg of protein
Control	3.79±0.4424	33.77±2.684	7.93±0.21	0.673±0.06346	0.621±0.0860
Scopolamine (0.4 mg/kg i.p.)	6.87±0.5511	64.99±1.621	4.788±0.511	0.34±0.04604	0.35±0.0484
LDAESV(200mg/kgp.o.)	6.62±0.9176	59.19±2.194	4.98±0.711	0.36±0.0506	0.39±0.0393
HDAESV(400mg/kgp.o.)	5.42±0.6161	47.46±2.653***	6.06±0.381*	0.553±0.07421**	0.49±0.0251**
LDEESV(200mg/kg p.o.)	5.48±0.4569*	56.66±3.299*	4.53±1.17	0.395±0.02074	0.42±0.065
HDEESV (400mg/kgp.o.)	4.15±0.618***	43.07±1.912***	6.69±1.39**	0.671±0.04708***	0.55±0.066**
Piracetam (400mg/kg i.p.)	4.005±0.4297***	37±1.767***	7.25±0.500***	0.72±0.05254***	0.65±0.0736***

n=6, Values are expressed as mean± SEM, one way ANOVA followed by Dunnett's test.

*P<0.05v/s scopolamine control, **P<0.01 v/s scopolamine control. ***P<0.001 v/s scopolamine control

CONCLUSION:

The whole plant of *Sida veronicaefolia* contain flavonoids, tannins, saponins, polyphenols, alkaloids, and glycosides. The aqueous and ethanolic extracts of *Sida veronicaefolia* improves learning and memory. This may be due to the antioxidant property of various phyto constituents like flavonoids, tannins, saponins, and polyphenols present in it. The results suggest that the aqueous and ethanolic extracts of *Sida veronicaefolia* reduced oxidative stress by reducing lipid peroxidation and increasing the endogenous antioxidant enzymes in brain. Thus the present study demonstrates that aqueous and ethanolic extracts of *Sida veronicaefolia* has potential anti-amnesic effects through inhibition of lipid peroxidation, augmentation of endogenous antioxidant enzymes and decrease in acetylcholinesterase (AChE) activity in rats.

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